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HEAVY METALS ANALYSES OF BOTTOM SEDIMENT IN THE POTOMAC RIVER ESTUARY

Thomas H. Pheiffer

Environmental Protection Agency
Annapolis, Maryland

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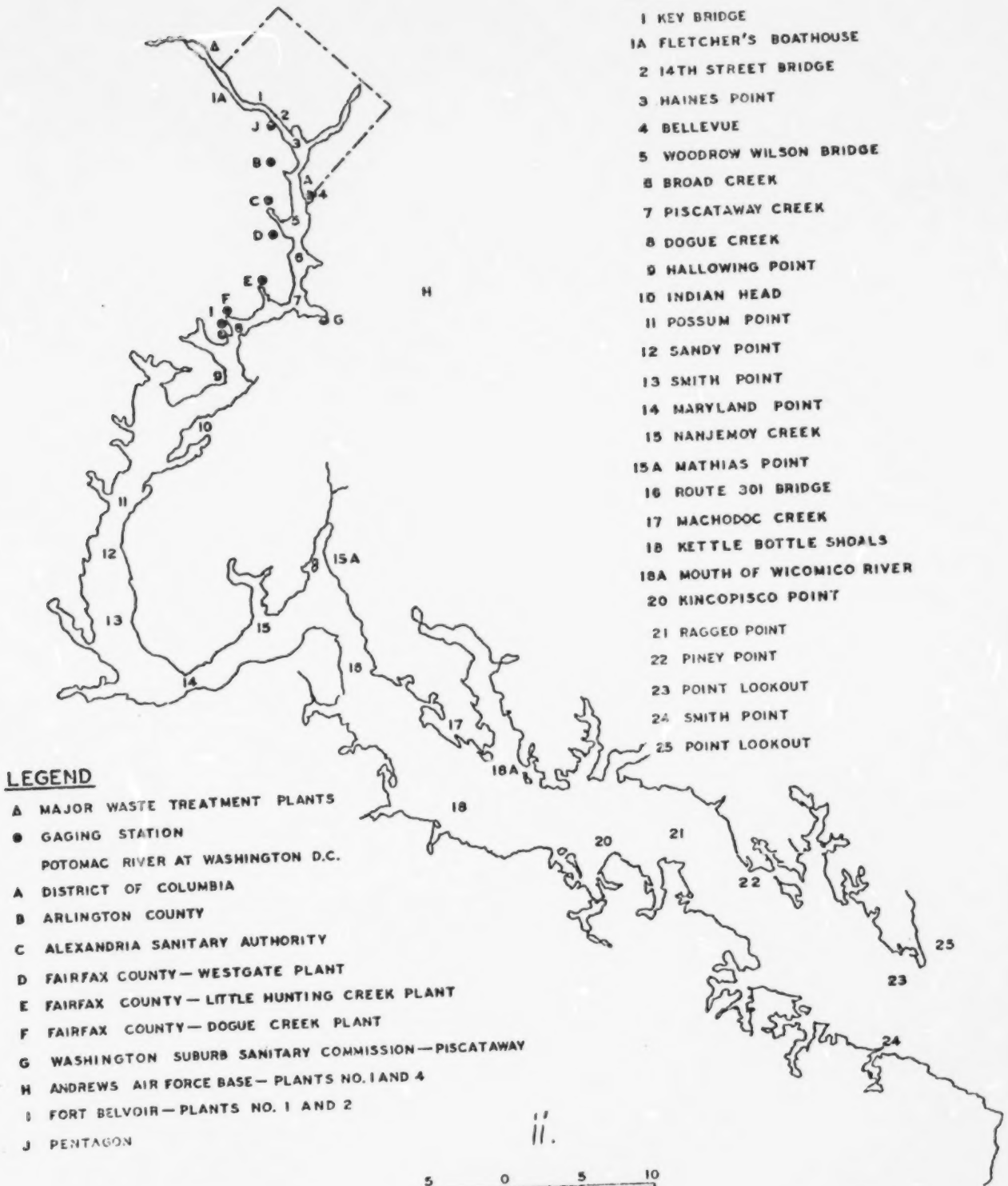
SAMPLING STATIONS



LEGEND

1 KEY BRIDGE
1A FLETCHER'S BOATHOUSE
2 14TH STREET BRIDGE
3 HAINES POINT
4 BELLEVUE
5 WOODROW WILSON BRIDGE
6 BROAD CREEK
7 PISCATAWAY CREEK
8 DOGUE CREEK
9 HALLOWING POINT
10 INDIAN HEAD
11 POSSUM POINT
12 SANDY POINT
13 SMITH POINT
14 MARYLAND POINT
15 NANJEMOY CREEK
15A MATHIAS POINT
16 ROUTE 301 BRIDGE
17 MACHODOC CREEK
18 KETTLE BOTTLE SHOALS
18A MOUTH OF WICOMICO RIVER
20 KINCOPISCO POINT
21 RAGGED POINT
22 PINEY POINT
23 POINT LOOKOUT
24 SMITH POINT
25 POINT LOOKOUT

LEGEND

A MAJOR WASTE TREATMENT PLANTS
● GAGING STATION
POTOMAC RIVER AT WASHINGTON D.C.
A DISTRICT OF COLUMBIA
B ARLINGTON COUNTY
C ALEXANDRIA SANITARY AUTHORITY
D FAIRFAX COUNTY — WESTGATE PLANT
E FAIRFAX COUNTY — LITTLE HUNTING CREEK PLANT
F FAIRFAX COUNTY — DOGUE CREEK PLANT
G WASHINGTON SUBURB SANITARY COMMISSION — PISCATAWAY
H ANDREWS AIR FORCE BASE — PLANTS NO. 1 AND 4
I FORT BELVOIR — PLANTS NO. 1 AND 2
J PENTAGON

11.

5 0 5 10
SCALE IN MILES

HEAVY METALS ANALYSES OF BOTTOM SEDIMENT IN THE POTOMAC RIVER ESTUARY

Recent detection of heavy metals in sediments of the Potomac River Estuary has raised sufficient concern to include accumulation of metals as a water quality problem requiring additional study and analysis.

A cooperative program of the Annapolis Field Office with the laboratory at the U.S. Naval Ordnance Station in Indian Head, Maryland,* was initiated to determine the occurrence of heavy metals in the Potomac Estuary and bottom sediment. Sediment analyses were made during August and September 1970, and again in April 1971. While small concentrations of zinc and manganese were detected in the overlying waters of the estuary, considerable amounts of various heavy metals were recorded by acid extraction determination from the sediment.

From the sediment analyses presented on the following pages it is evident that there are significant increases of lead, cobalt, chromium, cadmium, copper, nickel, zinc, silver, barium, aluminum, iron, and lithium in the upper estuary in an area above the Woodrow Wilson Bridge in excess of concentrations measured above and below

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*The analyses of all metals with the exception of mercury were performed in the Research and Development Laboratory of the U.S. Naval Ordnance Station, Indian Head, under supervision of Dr. M. I. Fauth, Director. Several of the figures were prepared at the Naval Ordnance Station and adapted for this report.

this area. Of the metals measured in April 1971, all showed increases in concentrations in this area, but the concentrations were lower than those detected in August and December of 1970. This could possibly be attributed to the high-flow conditions of February and March 1971 causing a more even distribution of metals below Woodrow Wilson Bridge. The data seem to support this observation.

High concentrations of wastewater components such as phosphorus and carton are found near the Blue Plains Wastewater Treatment Plant outfall. Since concentrations of heavy metals are greatest in this same area, it can be concluded that some heavy metals originate in the wastewater discharges in concentrations below detectable limits. Some accumulations such as cadmium and lead are caused by corrosion in water supply distribution systems. Schroeder reported that one major source of human cadmium consumption has been traced to soft water that flows through and picks up cadmium from water mains and pipes in houses [1]. The Potomac River raw water supply is considered medium hard, averaging yearly 100-110 ppm calcium carbonate. Other metals might be attributed to small commercial enterprises involved in printing or metal plating, for example. There are no industries in the Washington area using metals on a scale comparable to those in the Baltimore Harbor and James River areas.

On June 8, 1971, core borings were taken adjacent to the Blue Plains Wastewater Treatment Plant outfall. Data on heavy metals measured in the cores is shown in the data section of this report. Chromium was detected at depths of 5 and 10 feet only, in equal concentrations of 0.03 mg/gm or 30 ppm. Zinc and copper were detected

at the 1-, 3-, 4-, 10-, and 18-foot levels. The highest concentration of zinc was 180 ppm at the 3-foot level, while copper was distributed uniformly at all measured levels at about 40 ppm. Lead was found to increase with core depth, except that lead was below the detection limit when measured at the 5-foot level. No attempt was made to determine the time required for the bottom sediment to accumulate to the measured depth of 18 feet.

The following comparisons are made between the data obtained from the core borings and upper sediment data obtained in April 1971 in the vicinity of the Blue Plains plant. The concentration of chromium in the upper 2 or 3 centimeters of sediment was 70 ppm compared to 30 ppm at boring depths of 5 and 10 feet. Copper and lead show similar behavior patterns in both the upper sediment and the 1-foot depth level, with both metals concentrated at 50 ppm and 30 ppm in the sediment and core mud, respectively. Zinc shows a fluctuating pattern of behavior in both the upper sediment and the core samples. This fluctuating behavior as it pertains to the upper sediment is discussed later in the report.

At Possum Point and Route 301 Bridge, 38.0 and 67.4 miles below Chain Bridge, respectively, the incidence of metals in bottom sediment increases significantly. While there were increases in quantities of most metals at the two sampling stations, the following showed increased concentrations when compared to the initial determinations in August 1970: barium, lead, iron, strontium, lithium, cobalt, magnesium, chromium, nickel, and potassium. At the Route 301 sampling

station, copper showed a sharp increase (731 ppm) in April 1971, while at Possum Point the April 1971 amounts were lower than those of August and December 1970. In most of the samples the accumulation of metals was greater in the vicinity of Route 301 Bridge.

It is concluded that some of the above increases in metal concentrations are related to the construction of steam electric generating plants in the area.

On the Virginia shore of the estuary near Possum Point, the 437.6 megawatt, fossil-fueled plant is operated by the Virginia Electric and Power Company (VEPCO). The Potomac Electric and Power Company (PEPCO) operates a larger 1,148.0 megawatt, fossil-fueled facility on the Maryland side of the estuary, directly downstream from the Route 301 Bridge. The PEPCO plant, however, did not begin continuous operation until May 1971. The plant started up briefly in early summer 1970, but ceased operating in late November of that year because of problems with the turbines. The cooling water systems of the VEPCO and PEPCO plants have rated capacities to utilize 400 mgd and 1,434 mgd, respectively. The VEPCO plant at Possum Point discharges to the estuary via Quantico Creek, while the PEPCO plant discharges its cooling water directly to the Potomac Estuary. Heat exchanges associated with these cooling systems and the quality of the water passing through the condenser tubing could have a corrosive effect on the plants' cooling systems, with subsequent release of metals to the discharged cooling waters. As a factor affecting water quality, chlorine is often added to the cooling water to control algae and

prevent fouling of the condenser system. The PEPCO plant employs a mechanical means to cleanse the condensers rather than the algacides used at older plants.

Field studies (1962-67) conducted by Mihursky [2] associated mortality and greening of oysters with cooling water discharges in a critical area of the Patuxent River Estuary when operations were started at the Chalk Point Steam Electric System in 1964. Roosenburg conducted a special study on copper greening in oysters as a part of Mihursky's thermal studies [3]. Roosenburg reported that copper levels and greening in oysters were highest at natural bars and tray stations near the Chalk Point's cooling water outfall and diminished with distance from the effluent canal. In 1968, Patrick [4] confirmed that oysters at Chalk Point were green due to copper.

The work reported above at the Chalk Point plant can be related to the high incidence of heavy metals found in the Potomac Estuary in the vicinity of power plants. Since the PEPCO plant only began continuous operation in May 1971, some of the heavy metals detected near the Route 301 Bridge may be associated with operation difficulties encountered in 1970 and actual plant construction. Fallout from air pollution sources such as traffic on the 301 Bridge or testing of weapons over open waters by the Dahlgren Naval Weapons Laboratory are other probable contributors of heavy metals in this area.

In addition to metal contributions from cooling water and wastewater sources, heavy metals are apparently entering the estuary from the air. Emissions from smokestacks and the burning of lead-containing gasolines contribute lead to the surrounding environment. Lead from

motor vehicle exhausts is entering the environment in amounts of two pounds per capita per year [1]. Nationwide, the consumptive use of coal per year contributes 830 tons of lead, 743 tons of arsenic, 255 tons of mercury, 150 tons of beryllium, and 100 tons of nickel[5]. An analysis of randomly selected crude oils and fuel oils revealed contamination by metals which included mercury, selenium, cadmium, arsenic, chromium, cobalt, and gallium [6]. Studies have been initiated by the Environmental Protection Agency to determine amounts of hazardous substances, such as heavy metals, in both sewage sludge and the byproducts resulting from incineration of sewage sludge. The major sources of air pollution in the Washington area during the July 27-30, 1970, temperature inversion were associated with high emissions of sulfur dioxide, nitrogen dioxide, and hydrocarbons along the Alexandria-Arlington Potomac River waterfront. The prime sources of the emissions were reported to be motor vehicles, the Potomac River Power Plant, the Arlington incinerator, and aircraft at National Airport [7]. Metal fallout was not determined in the Washington study. The fallout of metals to the estuary from gaseous sources and the amount and distribution of the various metals should be determined.

Not all the metals data presented in this report can be associated with a critical estuarine area. Often a metal exhibited an erratic distribution pattern during one sampling period and then showed a more uniform pattern of distribution throughout the estuary during one of the other sampling phases. Of particular interest is the behavior of calcium, manganese, and zinc, indicated in the sediment analyses. At river miles 70 and 80 (miles below Chain Bridge) the December 1970

concentrations of calcium exceeded the August 1970 concentrations by several thousand ppm. These high concentrations were found in the saline portion of the estuary. With the natural seawater concentration of elemental calcium being 400 ppm, calcium can be expected to fluctuate in the lower and middle reaches of the estuary because of the considerable alkalinity intrusion from the Chesapeake Bay. Calcium will also be distributed throughout the estuary in carbonated forms due to the upper basin runoff and naturally occurring atmospheric transfer of carbon dioxide [8]. In addition, shell deposits from molluscs which contain calcium are widely distributed in the estuary. It should be noted that magnesium and strontium are also present in seawater at 1,350 ppm and 8 ppm, respectively.

Between river miles 40 and 50 a concentration of about 5,000 ppm of manganese was measured in bottom sediment during August 1970. A lower but significant concentration, approximately 3,300 ppm, was measured in December 1970 in the same area. Concentrations did not approach this order of magnitude in any other segment of the estuary. There is no apparent reason for this finding.

Concentrations of zinc measured in August 1970 and April 1971 show an even pattern of distribution throughout the estuary. The December 1970 sampling run showed concentrations of zinc fluctuating sharply from station to station. There is no explanation for the December 1970 zinc fluctuations except that freshwater flows entering the estuary increased from 4,000 mgd in the beginning of the month to 40,000 mgd towards the end of December. Zinc has also been detected in other estuaries of the Chesapeake Bay. Huggett *et al.* have found

significant concentrations of zinc in oysters (Crassostrea virginica) in Virginia estuaries of the Bay. The initial findings of these studies indicate that highly industrialized areas of the lower James River Estuary are contaminating the oysters in that area with zinc [9].

Although mercury is not included in the data set forth at the end of this report, sediment samples were analyzed for mercury. The concentration of mercury was found to be below the detection limit in practically all samples analyzed. Exceptions were detections noted at Piscataway Creek, Hallowing Point, Indian Head, Possum Point, and Sandy Point during December 1970, at which time the concentrations measured were 26.2, 5.0, 5.0, 5.6, and 4.7 ppb, respectively.

Arsenic, antimony, boron, bismuth, lanthanum, molybdenum, selenium, tin, and zirconium were included in the list of metals to be measured. However, the concentration of these metals was found to be below the detection limit in all samples.

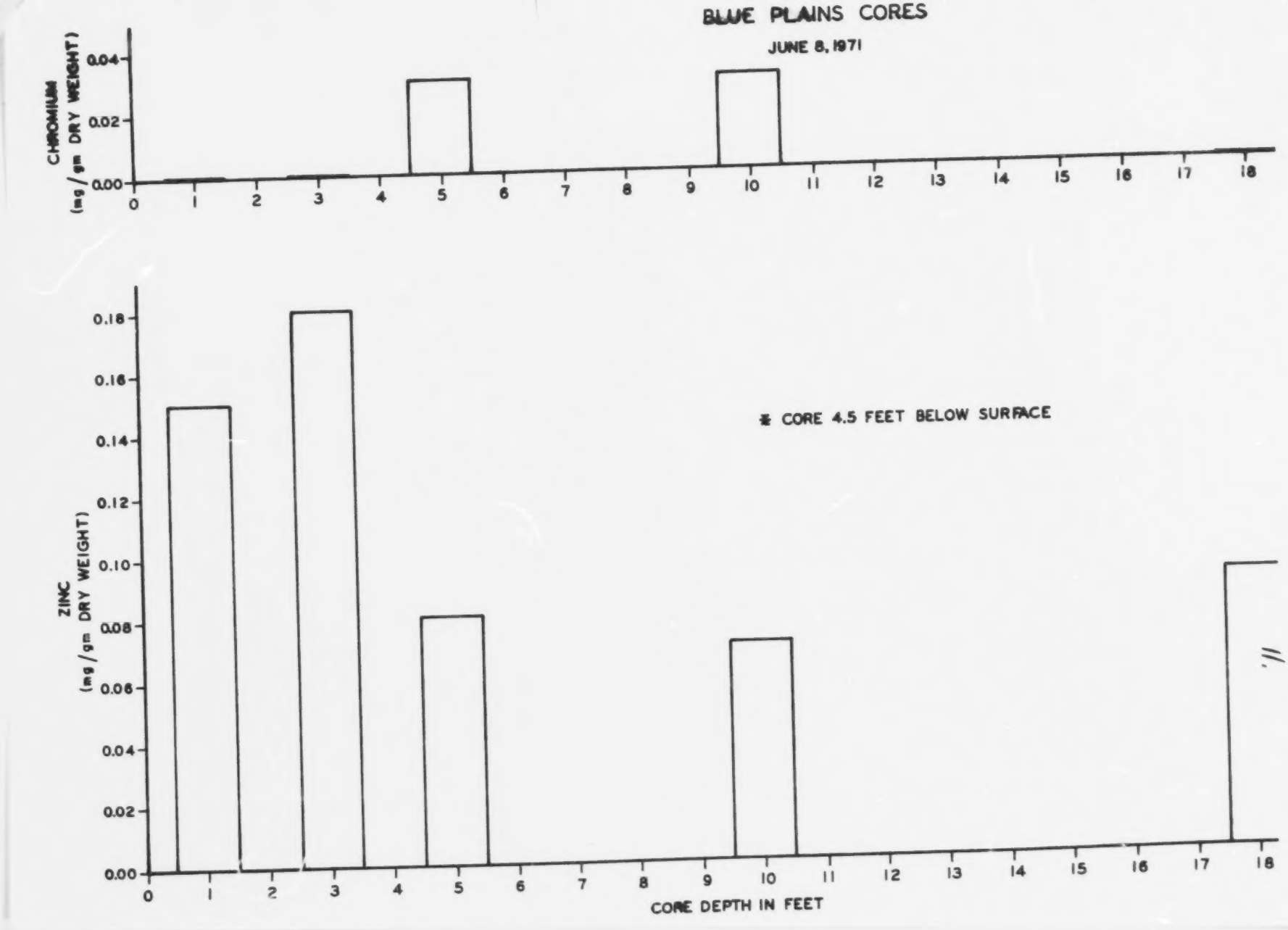
Heavy metals in the Potomac Estuary are chemically bound in bottom sediment and required heat and a low pH induced by acid in the laboratory procedure employed to extract them from the sediment samples. These metals, and the possibility of their remineralization into the overlying water, must be considered in the disposal of dredged spoil. Dredging operations involving deepening and widening of the channels near Washington, construction of piers and marinas, etc., disturb the sediments and require disposal of the dredged spoil. Should dredged material containing known high concentrations of potentially toxic metals be deposited in open waters of the estuary during high flow

conditions, colloidal suspension of the fine clay sediments with adsorbed metals could be transported downstream to the economically important shellfish growing areas. The metals could then be taken up by filter-feeding organisms which pump water through their digestive systems with probable accumulations of metals occurring in the organisms.

It should be noted that the synergestic effect of heavy metal accumulations on the ecology of the Potomac Estuary is indeterminate. Since the lower estuary is a prime shellfish production area, studies of the availability and effect of heavy metals on the biota should be undertaken. Surveys and monitoring activities should be carried out to determine the amount of heavy metals coming from the following sources: wastewater and cooling water discharges, disposal of dredged spoil, and heavy metal fallout from polluted air. Precipitation studies should be carried out to measure heavy metal pickup from snow and rainfall and the extent that these metals reach the estuary from soil runoff in the basin.

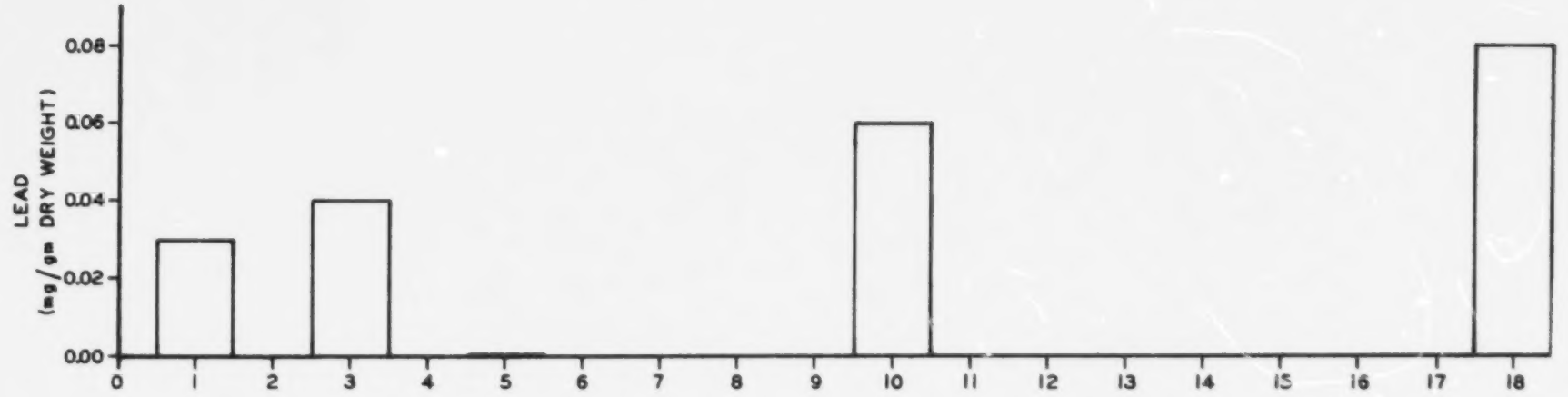
The Virginia Institute of Marine Science and the Chesapeake Biological Laboratory of the University of Maryland have initiated investigations to gather information on the effects of heavy metals on the estuarine ecology of the Chesapeake Bay system. The Chesapeake Biological Laboratory will try to determine in the laboratory and field the various environmental conditions affecting the uptake of metals by oysters. The Virginia Institute of Marine Science has conducted surveys in the Rappahannock, York, and James River Estuaries

to determine heavy metal concentrations in oysters. In this work involving bioassay techniques, steps are taken to utilize metal concentration relationships in the Eastern oyster (Crassotrea virginica) to detect heavy metal pollution in Virginia's major rivers.

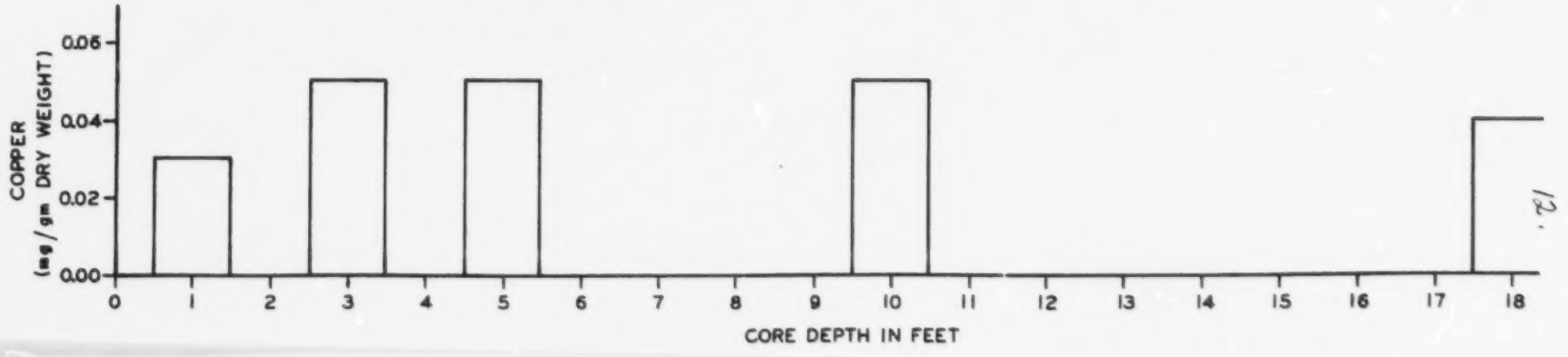

BLUE PLAINS CORES
JUNE 8, 1971
CHROMIUM (mg/gm DRY WEIGHT)
0.04
0.02
0.00
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
ZINC (mg/gm DRY WEIGHT)
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
* CORE 4.5 FEET BELOW SURFACE
CORE DEPTH IN FEET

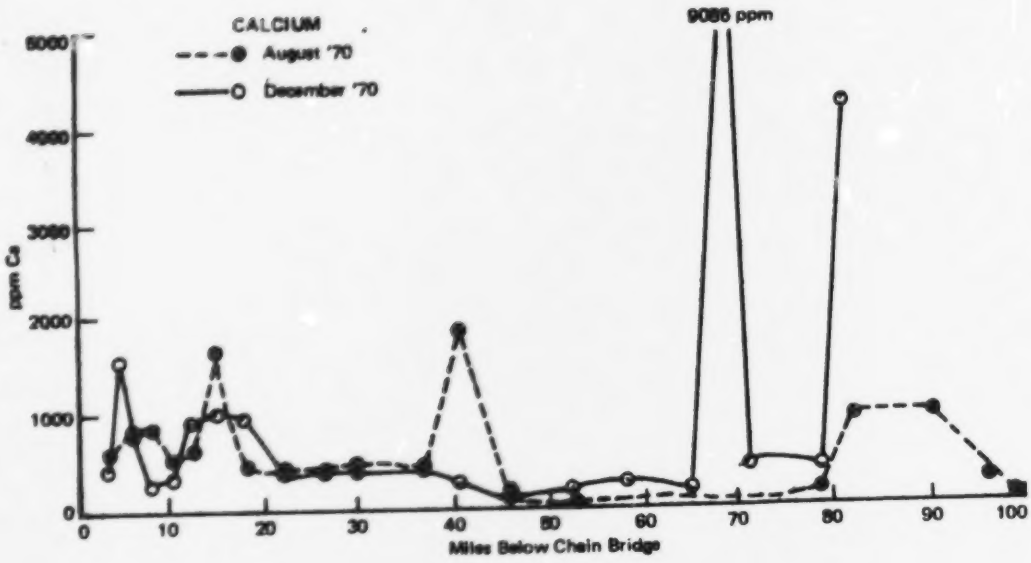
BLUE PLAINS CORES

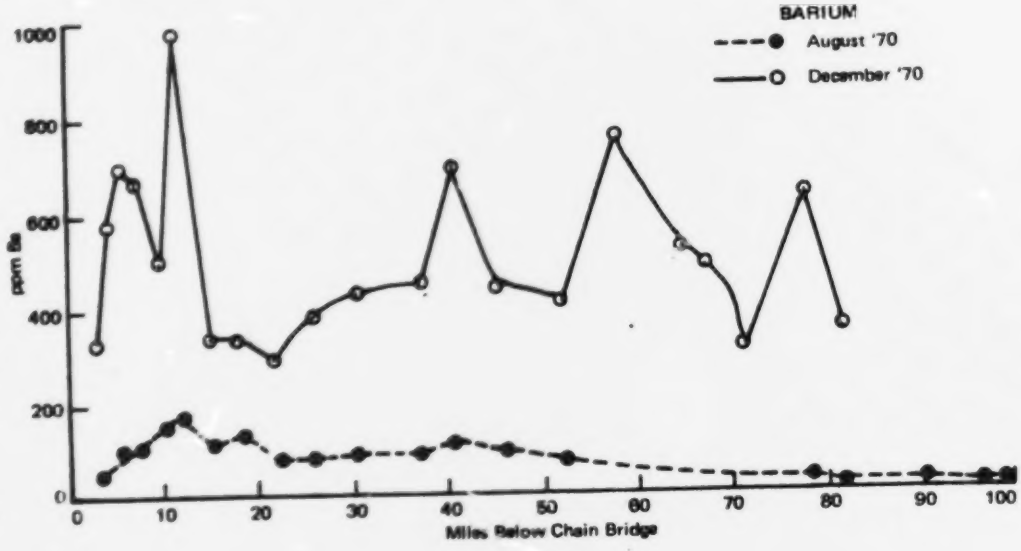
JUNE 8, 1971

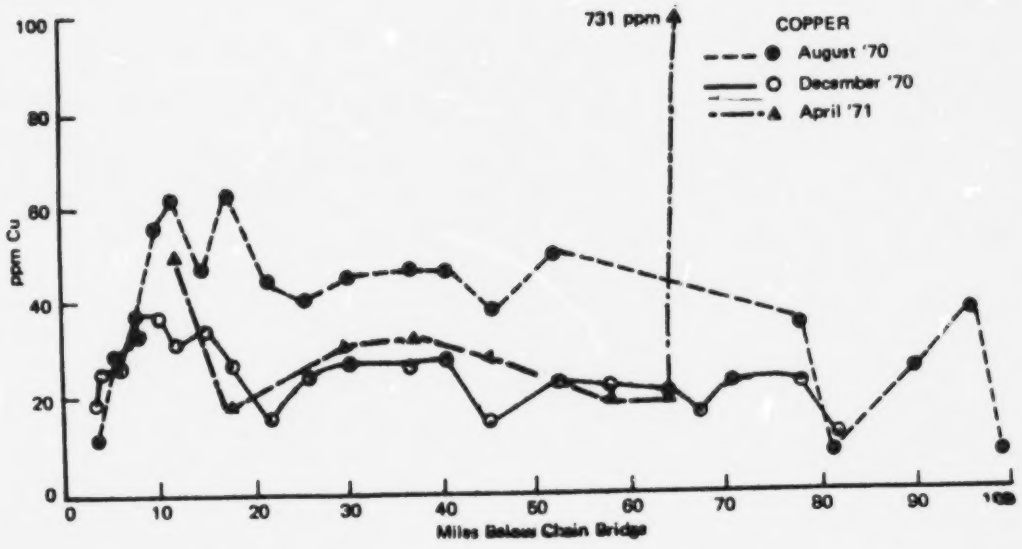


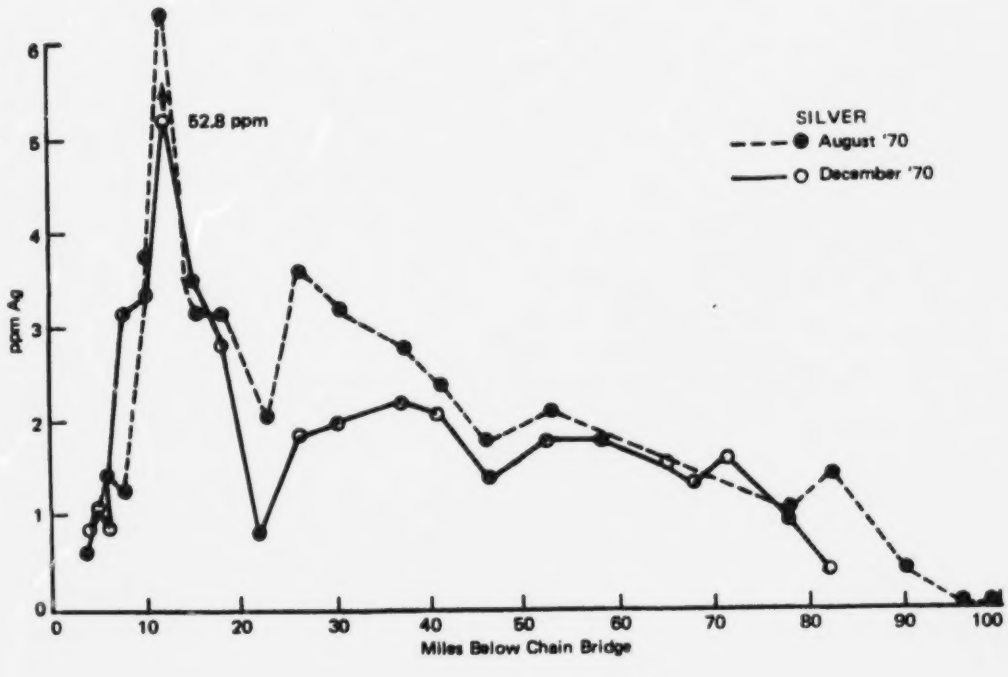
CORE 4.5 FEET BELOW SURFACE

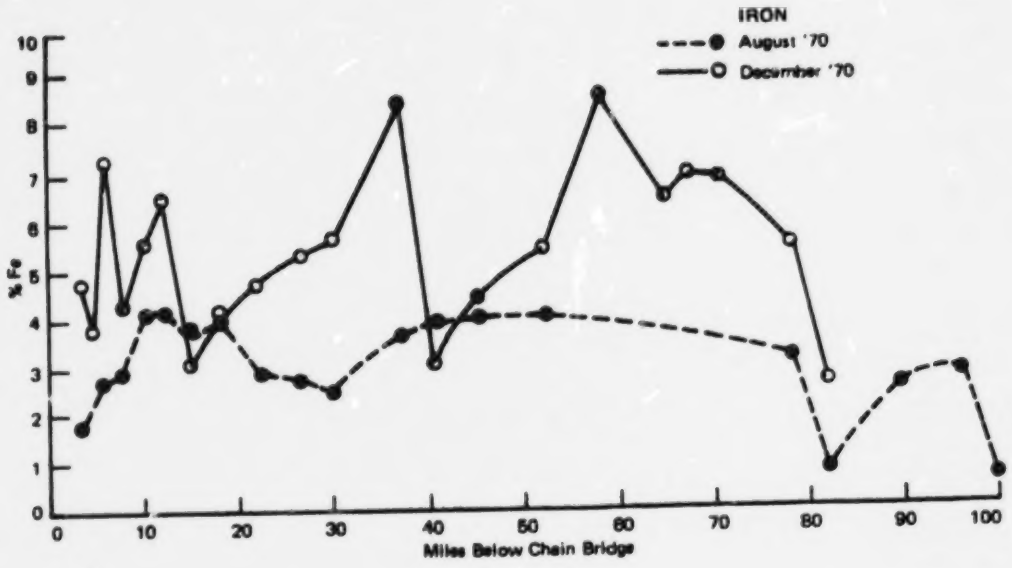


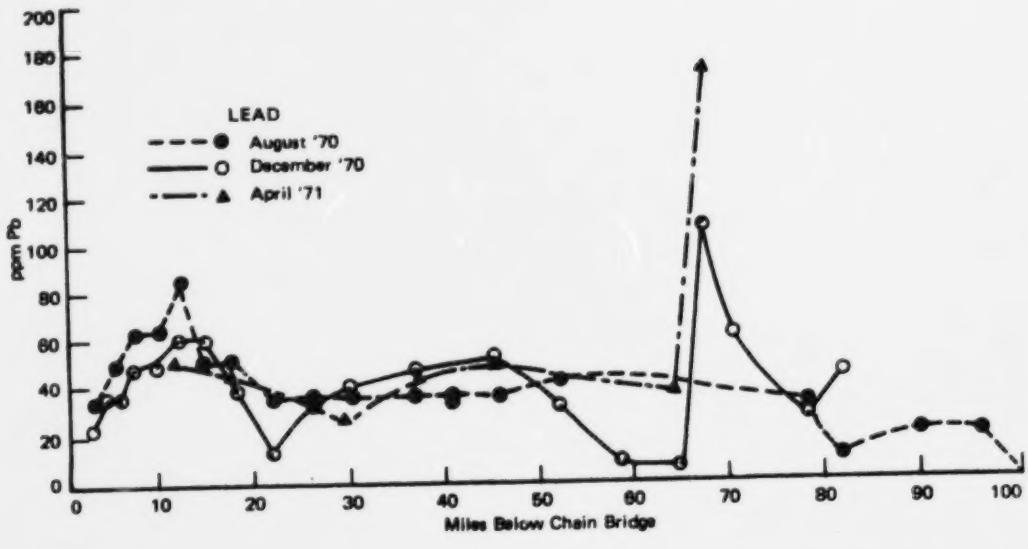

CALCIUM
August '70
December '70
9086 ppm
ppm Ca
8000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
100
Miles Below Chain Bridge

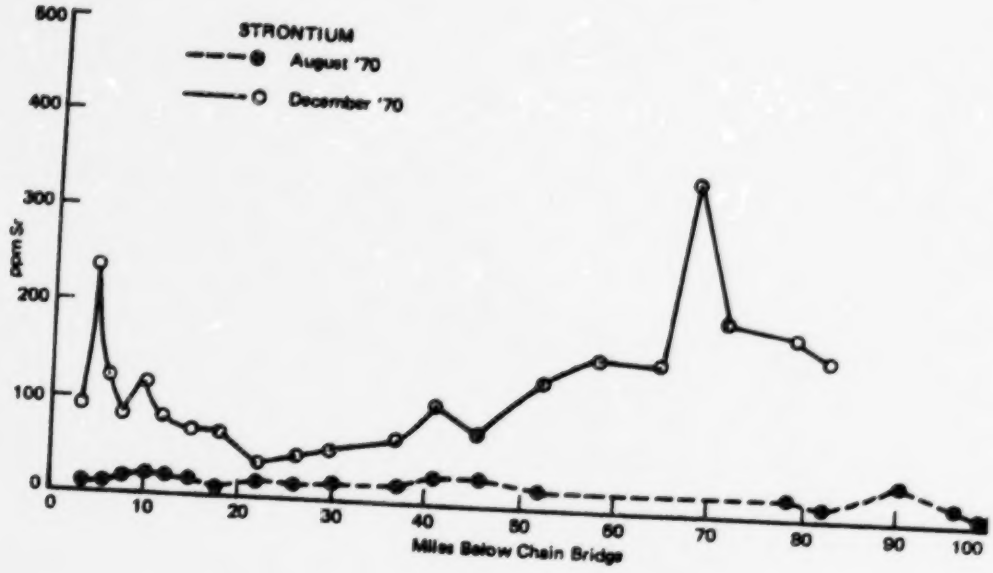

BARIUM
August '70
December '70
ppm Ba
1000
800
600
400
200
0
0
10
20
30
40
50
60
70
80
90
100
Miles Below Chain Bridge

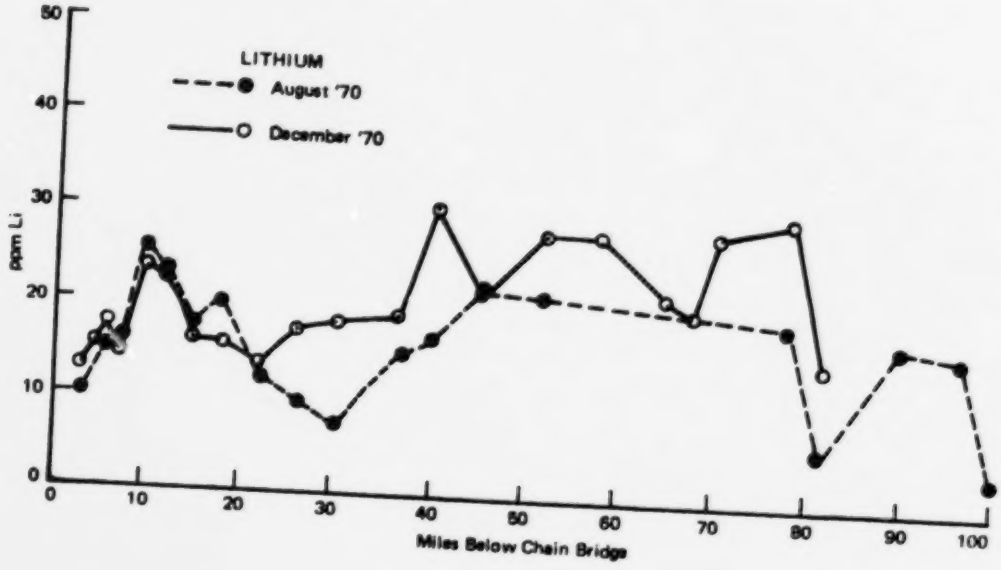

731 ppm
COPPER
August '70
December '70
April '71
ppm Cu
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
90
Miles Below Chain Bridge

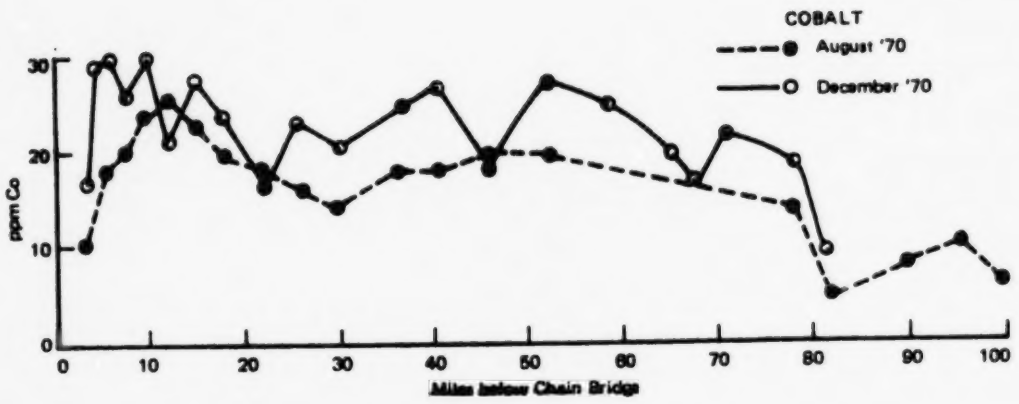

52.8 ppm
SILVER
August '70
December '70
ppm Ag
6
5
4
3
2
1
0
0
10
20
30
40
50
60
70
80
90
100
Miles Below Chain Bridge

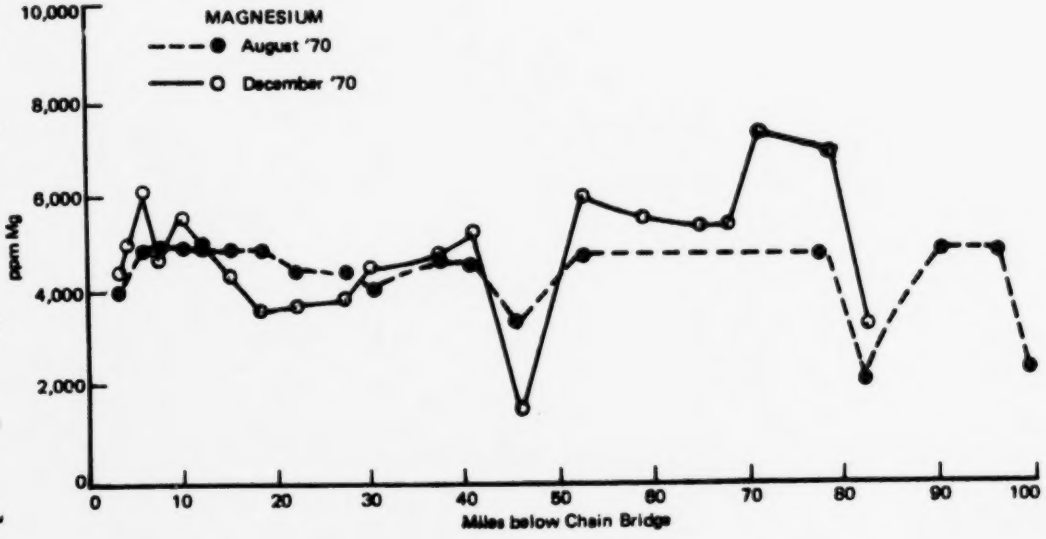

IRON
August '70
December '70
% Fe
0
1
2
3
4
5
6
7
8
9
10
0
10
20
30
40
50
60
70
80
90
100
Miles Below Chain Bridge

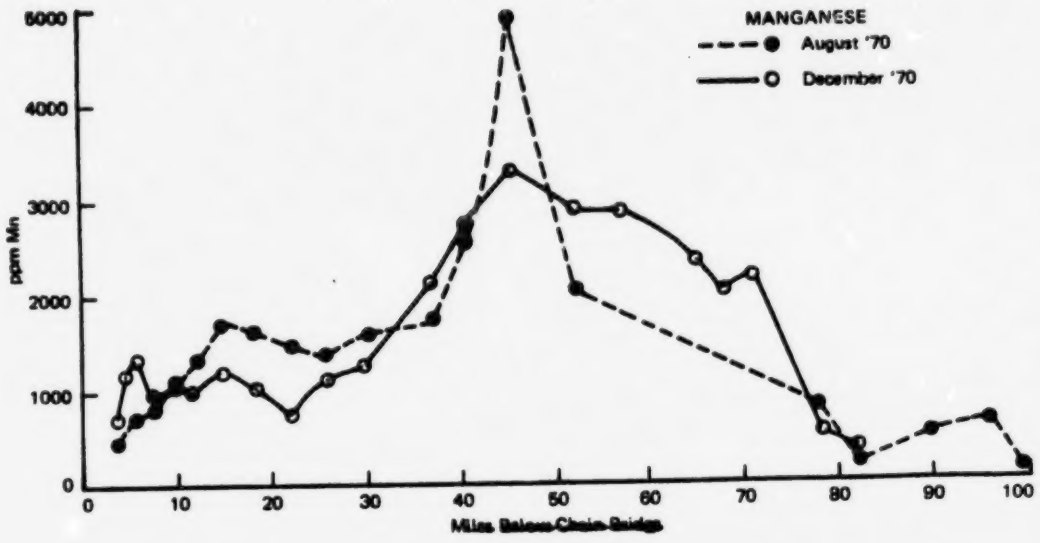

LEAD
August '70
December '70
April '71
ppm Pb
0
20
40
60
80
100
120
140
160
180
200
0
10
20
30
40
50
60
70
80
90
100
Miles Below Chain Bridge

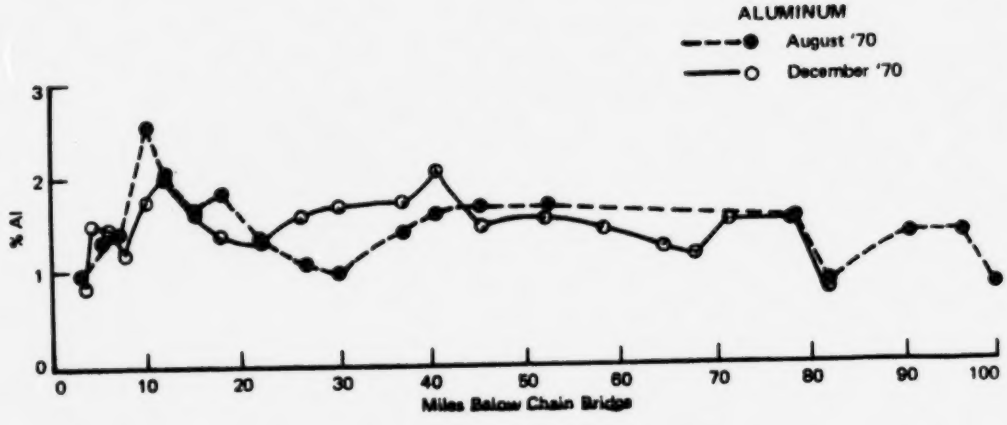

STRONTIUM
August '70
December '70
ppm Sr
500
400
300
200
100
0
0
10
20
30
40
50
60
70
80
90
100
Miles Below Chain Bridge

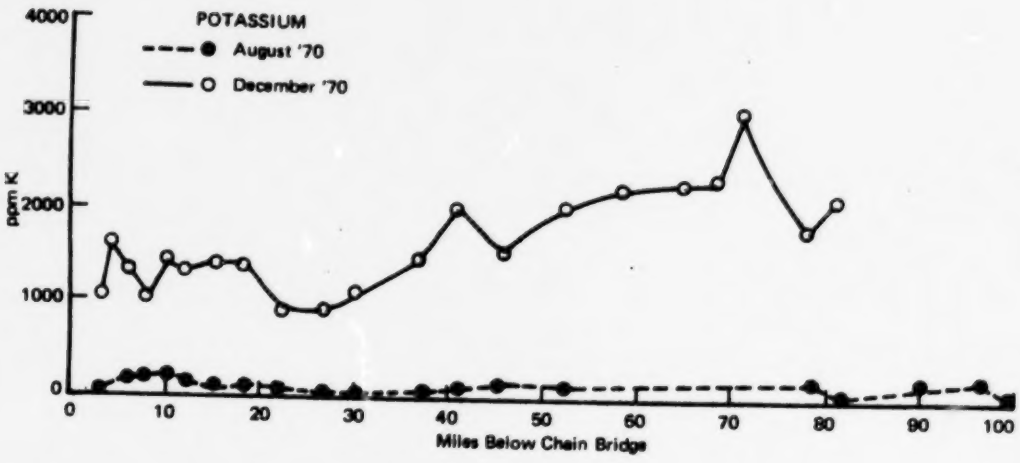

LITHIUM
August '70
December '70
ppm Li
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
Miles Below Chain Bridge

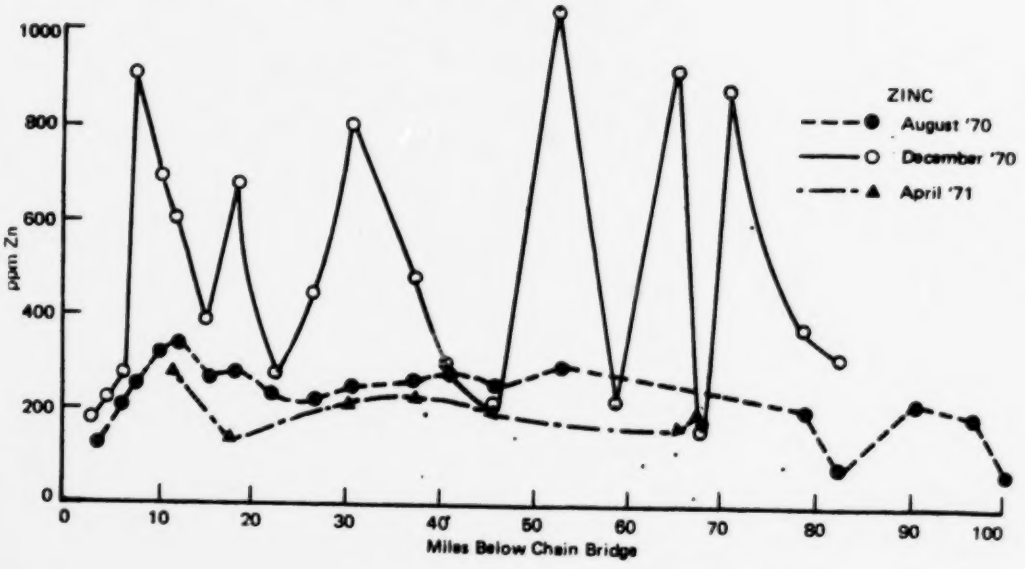

COBALT
August '70
December '70
ppm Co
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
Miles below Chain Bridge

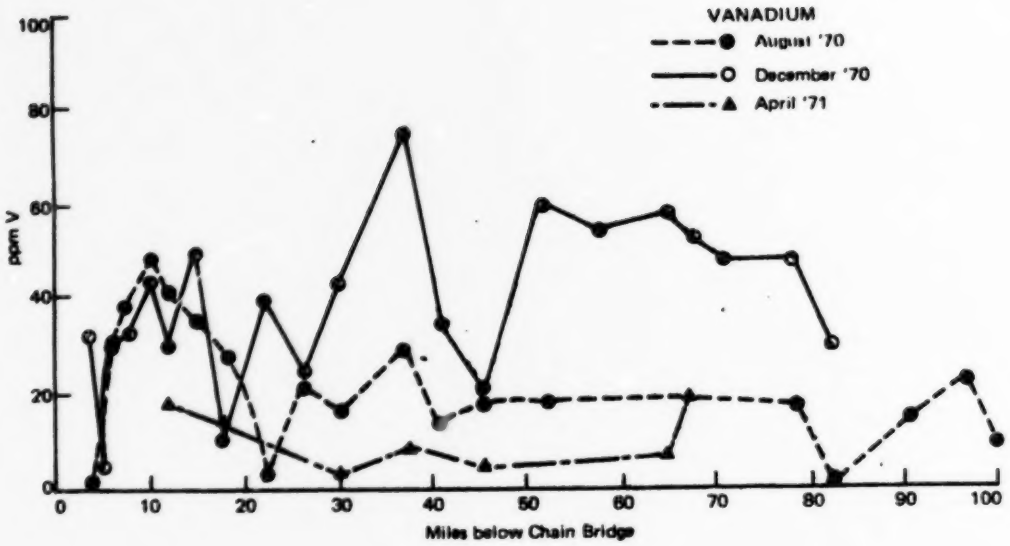

MAGNESIUM
August '70
December '70
ppm Mg
10,000
8,000
6,000
4,000
2,000
0
0
10
20
30
40
50
60
70
80
90
100
Miles below Chain Bridge

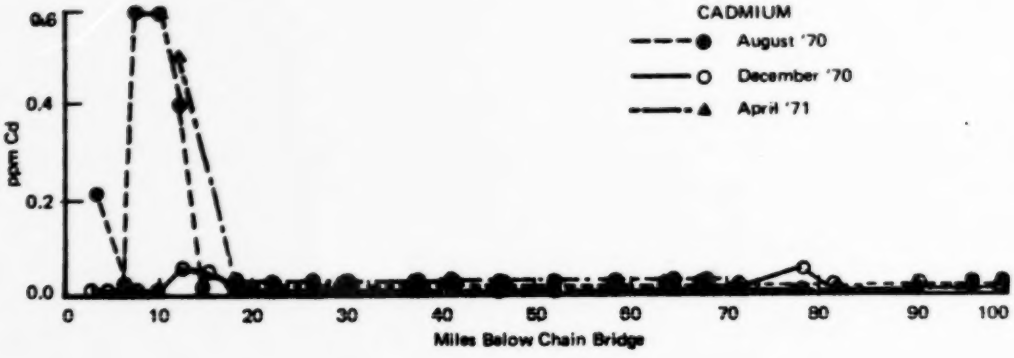

MANGANESE
August '70
December '70
ppm Mn
0
1000
2000
3000
4000
5000
0
10
20
30
40
50
60
70
80
90
100
Miles Below Chain Bridge

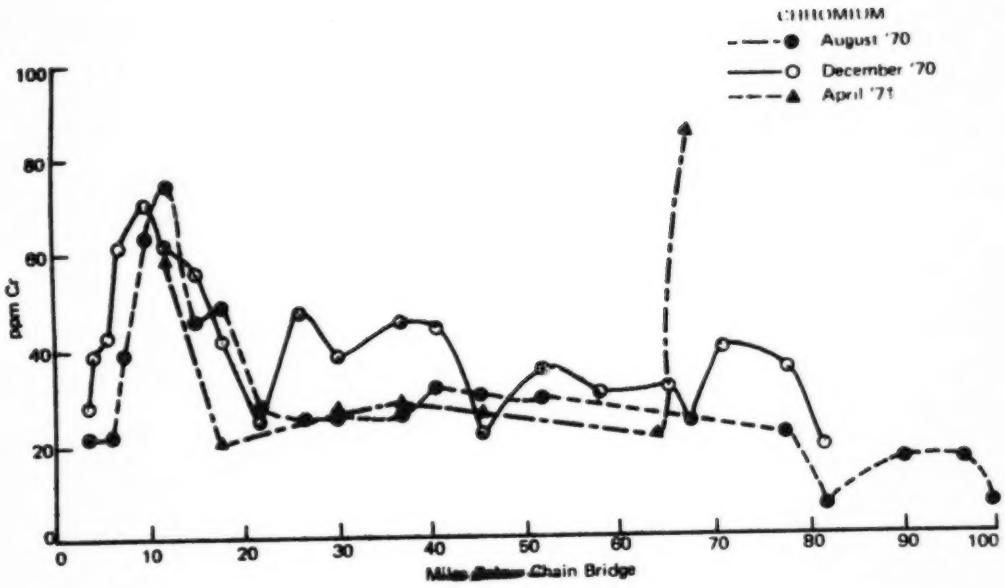

ALUMINUM
August '70
December '70
% Al
0
1
2
3
0
10
20
30
40
50
60
70
80
90
100
Miles Below Chain Bridge

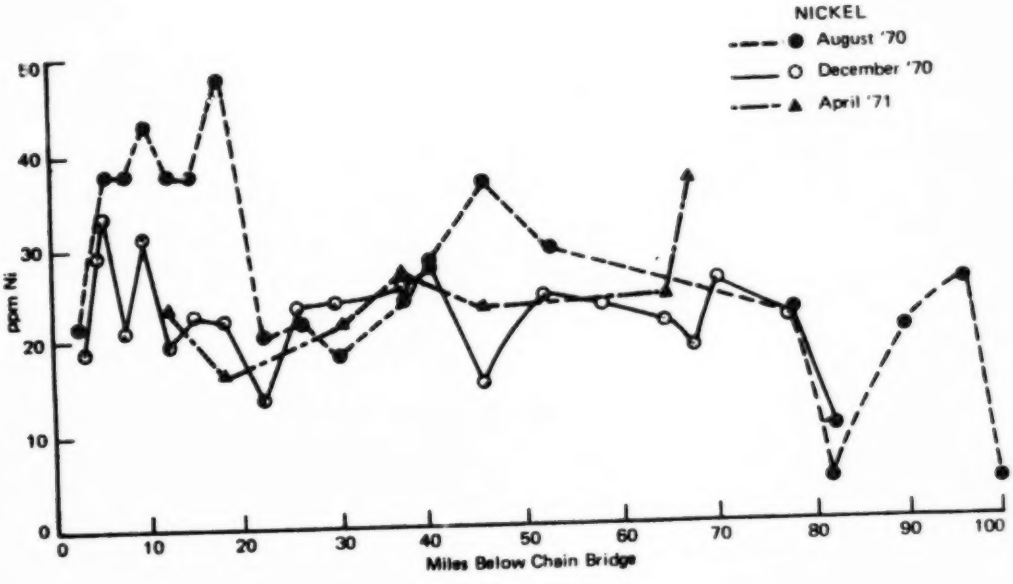

POTASSIUM
August '70
December '70
ppm K
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
100
Miles Below Chain Bridge


ZINC
August '70
December '70
April '71
ppm Zn
1000
800
600
400
200
0
0
10
20
30
40
50
60
70
80
90
100
Miles Below Chain Bridge


VANADIUM
August '70
December '70
April '71
ppm V
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
90
100
Miles below Chain Bridge


CADMIUM
August '70
December '70
April '71
ppm Cd
0.6
0.4
0.2
0.0
0
10
20
30
40
50
60
70
80
90
100
Miles Below Chain Bridge


CHROMIUM
August '70
December '70
April '71
ppm Cr
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
90
100
Chain Bridge


NICKEL
August '70
December '70
April '71
ppm Ni
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
Miles Below Chain Bridge

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